The Future of the Grid

Evolving to Meet America's Needs

Northeast Region Workshop Summary

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New York, New York

GRIDWISE ALLIANCE

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Introduction

The U.S. electricity system is undergoing a major transformation that will continue for the next 25–30 years. The rapid evolution of electricity supply and end use will have major implications for reliability, transmission and distribution, consumer engagement, security, and integration.

Regardless of the ultimate generation mix or the policies in place, the electric grid will play a critical role in future electricity infrastructure. In fact, it is an essential, enabling platform that supports America's economic activity, similar to the cellular network, which enabled the world of smartphones and mobile applications.

Thoughtful debate and planning are needed today in order to address tomorrow's challenges and seize on tomorrow's opportunities. With this in mind, the GridWise Alliance (GWA) and the U.S. Department of Energy's (DOE's) Office of Electricity Delivery and Energy Reliability (OE) hosted a series of workshops across the country (four regional workshops followed by a national summit) to develop an industry-driven vision of the nation's future electricity grid. During the regional workshops, thought leaders from all stakeholder groups (utilities, regulators, state government officials, renewable energy providers, suppliers, and industry innovators) came together to define the needed capabilities, the changing role of grid operators, the new technologies and financial models required to drive investment, and the policy and regulatory barriers to realizing the vision.

Figure 1. Workshop region designations

The region designations for the regional workshops are identified in Figure 1 and align along Independent System Operator (ISO)/Regional Transmission Organization (RTO) markets. California, because of its unique characteristics, was included in both the Western and Central Region workshops.[1]

Following the regional workshops, a national summit will take place in Washington, DC, to review, synthesize, and validate the findings and themes that emerge from the regional discussions. The results from this effort will inform larger DOE efforts to help guide research and development (R&D) agendas and serve to educate all stakeholders—including state and federal policy makers and regulators—on the issues that must be addressed to ensure that the future grid is affordable, reliable, and resilient to support economic prosperity and energy security.

[1] California is geographically aligned with the Western Region and shares many renewable energy and environmental drivers common to other Western Region states. California is also aligned with the Central Region in terms of its use of an ISO to regulate its wholesale market and the nature of the utility-consumer relationship.

Workshop Approach

The structure of each of the four regional workshops is the same. The day begins with a visioning exercise in which participants are asked to forget the current legacy system and think about the type of system they would design today if starting anew. Participants are then split into breakout groups, each of which is given a different scenario to discuss considering a future state of the grid in 2030. The breakout groups then participate in facilitated discussions to answer questions about grid capabilities, grid operations, business models and investments, and regulatory and policy barriers and opportunities in the context of their assigned scenario, while keeping in mind the vision for the future grid. The workshops feature open and frank discussions by employing Chatham House Rules, which permit participants to speak freely without the fear of attribution. The complete workshop agenda for the Northeast Region workshop can be found in Appendix B.

Although the scenarios are anchored in key factors affecting the grid, they do not represent an exhaustive examination of what is possible in 2030. Instead, they highlight the most likely scenarios and key areas that are plausible and facing industry today. The scenarios serve to guide the discussion of "2030 grid operations" from important and somewhat different perspectives. Participants are asked not to debate whether the scenario will occur, but to consider what new technologies, capabilities, or policies would be needed or what limitations might exist to transform today's system into the future vision.

The same scenarios are discussed at each workshop:

- Balancing Supply and Demand as Grid Complexity Grows
- Involving Customers and Their Loads in Grid Operations and Planning for Empowered Customers
- Higher Local Reliability through Multi-Customer Microgrids
- Transitioning Central Generation to Clean Energy Sources—Large Wind, Large Solar, and Large Gas

Regional differences have emerged from the different workshops as these scenarios are discussed throughout the country. These differences are included in each region's stakeholder-driven vision and will be captured as part of the broader national-level vision.

The Northeast Region workshop—the fourth in this series—took place in New York, New York, on May 13, 2014. Fifty-seven participants attended the workshop; Figure 2 shows the breakdown by stakeholder group. The complete list of attendees is provided in Appendix C.

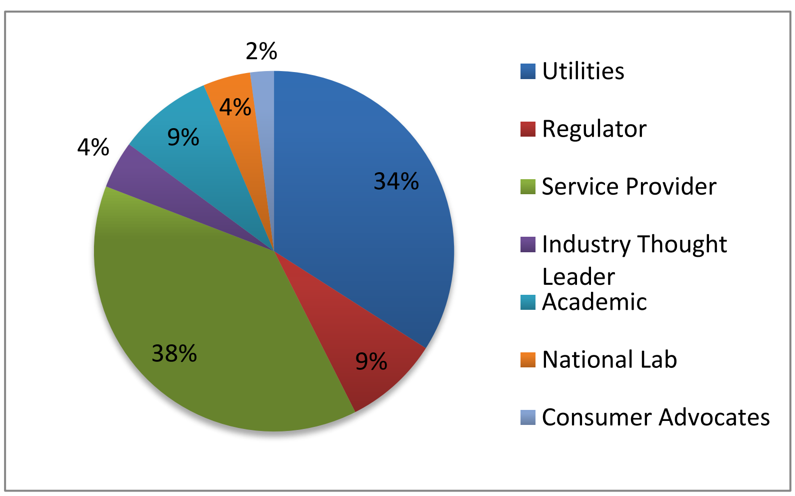

Figure 2. Breakdown of Northeast Region workshop participants

Participants were given an extensive set of pre-read materials before the workshop describing the scenarios and highlighting factors to consider. These materials set the stage for the workshop and provided context for the discussions. Appendix A contains a summary of the key factors participants were asked to consider.

Key Findings

Participants at the Northeast Region workshop noted the value of convening stakeholders in a forum that permitted all perspectives to be heard. Participants appreciated the opportunity to gather with peers to discuss and debate these important topics. Throughout the discussions, several key themes emerged about the likely characteristics and expected needs of the electricity grid in 2030:

Overarching

- **The planning of the grid has to be more open and transparent.** Having a vision is important, but the transparency of the planning process and the path is also a critical element. Planning needs to be open to all stakeholders so their priorities and perspectives can be taken into account.
- **The grid will need to be flexible to support a variety of goals and policy objectives.**
- **Physics—what is operationally possible—is not driven by economics.** This must be kept at the forefront of decisions.

Operations

- **Grid operations will be increasingly complex.** Large penetrations of distributed generation will significantly increase the complexity of grid operations.
- **The grid will leverage two-way power flows across the system, and greater visibility and predictability will be needed from transmission down to the end device.** Information will be exchanged in near real time with low latency. Tools and software will exist that enable the grid to operate in an optimized cost environment with more distributed assets.
- **There will be a merging of distribution and transmission systems.** Operations will blur and information will be exchanged between the two systems in near real time, with more integrated coordination between the two. The vertical exchange of information will be automated, enabled, optimized, and regulated by the development of interface standards.
- **The integration and synchronization of distributed generation and microgrids will become key components of distribution system operations.** Seamless transitions and interfaces will be needed.
- **Operations will be more predictive rather than reactive.** Increased data—measured and verified with greater granularity—will provide more insight into the behavior of the grid. This will support the forecasting of both energy production and energy demand.
- **A shift will occur away from inertial energy storage and toward battery storage.**
- **Consumers' obligations to the grid as well as utilities' obligations to consumers will be clearly delineated.**
- **The grid will operate as a centralized-decentralized hybrid, and the distribution system may be the heart of the future grid.** Central generation and microgrids/distributed generation will complement each other. The grid will feature decentralized control and operational "brains" (distributed intelligence) scattered along the system. Utilities will play the coordination role in the decentralized grid.
- **There will be vertical-horizontal integration.** Operations within an organization's/utility's (vertical) domain are expected to collaborate with other (horizontal) entities that also interact with the grid (e.g., microgrids).

Business Models and Pricing

- **There will be a new market at the distribution level, and grid operators could facilitate/coordinate retail and wholesale markets or market exchanges**. Utilities will be intelligent network managers. There will be numerous markets for numerous products, and utilities will be paid for network services rather than just for power delivered.

- **Utilities will provide services in addition to traditional power delivery, and market rules will need to be developed.** It will be necessary to define what is considered basic service.
- **Utilities and/or third parties will provide consumer meter-side products and services**. Products/services could include applications ("apps"), packaging of data, ancillary services/reactive energy/regulation services, and third-party storage providers.
- **There will be a shift to a performance-based model rather than a commodity model.** This shift will require performance-based incentives and penalties, as well as performance metrics.
- **With prices on the grid edge falling and prices on the central grid rising, there is a risk that increased costs will force a large percentage of consumers from the grid.** It will be important to consider how to maintain the current central grid while also enabling distributed services. Declining sales as a result of increased distributed energy resources must be offset with fees (backup charges) to recover the utility's fixed costs so there is not a new "energy divide" created between those who can leverage distributed energy resources and those who cannot due to price, location, or preference.

Policy

- **Different models for the ownership and purpose of microgrids are needed, as well as homogeneous standards for microgrid interconnection.**
- **Rate structures need to change** to incentivize a shift in business models and innovation. To incentivize innovation, least-cost rates need to give way to the incorporation of social values and externalities. Least-cost, risk-averse approaches will not yield innovation.
- **Changes are needed to generation ownership rules, which currently constrain the deployment of new technologies (e.g., microgrids and energy storage).**
- **There is a lack of clarity (from both regulators and consumers) regarding cost components.** The components that make up electricity bills must be clear. Consumers must clearly understand the services they are receiving, the value of those services, future needs for the infrastructure, and why future investments are necessary.
- **Much shorter payback periods for funding/investment requirements are needed.** There is a much shorter time frame for technologies now. Established asset lives for new technologies should be revisited.
- **Rate proceedings should be changed to enable regulation to be done at the speed of business.** They should feature a longer time horizon, be forward looking, and include metrics-based outcomes.
- **There is an opportunity to establish uniformity of regulation or baseline regulation that covers all 51 jurisdictions, which would enable the creation of national standards and a uniform market for vendors and investors.** A national standard for regulatory structure would allow the creation of a bigger market for entities offering a new product or service.

Summary of Messages to Policy Makers

During the breakout sessions, participants identified the most important messages for policy makers to consider when developing future policies:

- **The grid is the enabler of the future.** Investments and policy need to help support the next-generation grid.
- **The past is not the possible future.** With the numerous changes taking place, the current method of operation cannot continue; the future will be different. It will need to be determined whether the conventional grid is simply being rebuilt or whether there is another solution. Policy makers should think outside the box and consider externalities such as social justice, environmental concerns, and new actors. There is a cost to doing nothing, so change must be confronted, not avoided.
- **Policy makers can enable change by helping to create a transparent framework that aligns benefits, cost, services, and the business model to encourage innovation and investment.** More leadership is needed in policy making to set standards that support innovation and investments in the industry.
- **No matter how much innovation occurs, some consumer segments will be left behind or will be unwilling or unable to participate.** They will need to be protected.
- **Technology wins.** Policy makers must support technological innovation and prepare for the impacts of truly disruptive technologies.
- **Consumers are not a monolith.** Different consumers have different needs, and there are unique challenges and requirements across neighborhoods, states, and regions.
- **There is no free lunch; everything has a cost.** Consumers will have to pay for these choices, so the benefits to different consumers have to be at the forefront of decision making.
- **Microgrid development presents an opportunity to show the world how the grid can evolve.** Microgrids provide an opportunity to demonstrate optimization of supply and demand for consumers, not just for utilities. A strong, integrated grid is required to support affordable multi-customer microgrids and other distributed resources. The distribution system will be the heart of the future grid.
- **Various incentive opportunities can encourage the development of microgrids.** For various reasons, utilities generally do not have much incentive for identifying microgrid development opportunities. However, taking into consideration consumer priorities, options for franchise flexibility, public-private partnerships, and state-driven initiatives, utilities may be encouraged to support microgrid growth.
- **Physics is not driven by economics.** The physics of producing and delivering electricity must be considered as new operating frameworks and business models are developed.
- **National laboratories can provide critical R&D, test beds, etc. to help the grid move forward.** Collaboration between utilities and national laboratories and researchers could enable greater sharing of resources to drive innovation.

Summary of Necessary Actions

During the breakout sessions, participants recommended actions that should be taken, as well as issues that must be considered, in order to facilitate the evolution of a cost-effective, reliable, and resilient grid of the future:

Overarching

- **Create a national policy that drives standards that support ubiquitous regulatory environments.** National standards are going to be a key component, but with so many entities, a common goal will need to be established.
- **Provide a transition plan to move from traditional business models to new, innovative models that preserve the existing infrastructure to ensure the resilience of the grid.** "Do not throw the baby out with the bath water." The grid is surprisingly resilient, and it should be rewarded. The transition will take a while, and different grid versions will need to coexist. Utilities need clarity about evolving changes so that they can plan accordingly and continue to provide services to consumers throughout the transition.

Operations

- **Make the investments needed to modernize the grid and enable the collection and better utilization of data to improve asset utilization and consumer services.** Concerning operations, electricity providers need to be able to implement twenty-first-century technologies to collect and use the data they need to improve operations. For example, numerous utility operators presently do not have many of the sensors for smart switching, nor do they have advanced metering infrastructure (AMI), which provides increased visibility. As a result, they are technologically behind other utilities. Data from these technologies is very valuable because of the knowledge and actionable conclusions that can be derived from it.

Business Models and Pricing

- **Apply performance-based incentive structures that include penalties for underperformance.** Performance metrics will be needed. There needs to be both positive and negative incentives for performing above and below targets, respectively.
- **Decouple revenue constructs and align incentives to encourage investment in new technologies and monetize performance-based services, including the following:**
    - Environmental impact.
    - Resilience.
    - Reliability.
    - Restoration time.
    - Energy efficiency and efficiency of operations.
    - Consumer experience.
    - Security.
    - Affordability.
- **Transition from a volume-based model to a service-based model, and allow utilities to provide and charge for a range of services.** For example, there would be a rate for basic service with additional services available a la carte.

Policy

- **Change the cost recovery model and ensure accountability.** There will need to be a transition toward performance-based rates. The rate structure should be changed so that actual costs are disaggregated into their logical components. New utility business models and investments should be aligned with policy objectives. It will be necessary to look across the integrated electric system to maximize value (e.g., break down silos) and fully recognize the role the grid plays. The economies of net metering should be limited to time-of-use rather than arbitrarily defined rate classes.

- **Incentivize R&D.** Reliability should be kept pure and sacred; it should not be confused with other constraints. Regulators should fund and build an intelligent, advanced digital network (communications and intelligence). Regulators, policy makers, and planners should plan for disruptive elements (e.g., storage, photovoltaics [PVs], vehicle to home, very-large-scale events, and other "killer" apps) so that utilities and the market can adapt. There is the question of what will happen when such technologies hit their new market segments.
- **Make the physics of the electric system a basic knowledge requirement for regulators; a greater understanding of the grid is needed.** For regulators to be able to understand the evolution of the electric system and the need to modernize the grid, they need a deeper understanding of how the system works. It is no longer enough just to understand traditional rate making.
- **Support the development of markets (e.g., distribution locational market prices), standards and technology, and integration to enable dynamic grid operation and optimization.** R&D should be accelerated on data/load control management at the distribution grid level. Although policy makers have concern that using the term "R&D" might represent moving too quickly, in fact, with the push for integrating increasing levels of distributed energy resources, it is essential that control management technologies evolve and are researched to effectively handle this new requirement. There should be technology integration/demonstrations. Dynamic distribution grid operations must be pursued.
- **Address legislative/regulatory/statutory certainties or changes at the federal, state, and local levels.** In many jurisdictions, regulators do not have the authority to drive/approve the types of business model changes that will be necessary. Policy makers may need guidance and assistance on what types of changes will be needed to enable this transition. New York's Reforming the Energy Vision (REV) initiative may prove to be a blueprint for how to create a new retail-level market. Rule-making should be considered in states where there is a desire to move in this direction.
- **Encourage and enable active stakeholder engagement.** Consumers and other stakeholders, including third-party innovators, should be fully engaged in the process of transforming the grid.
- **Ensure transparency in the process and path of grid evolution.** The focus should not just be on the vision, but also on the process and path. Open, transparent involvement in the process by all stakeholders is necessary.

Opening Remarks

The Honorable Patricia Acampora, Commissioner with the New York State Public Service Commission, presented the opening remarks. She described the Commission's new Reforming the Energy Vision (REV) initiative, which will reform New York State's energy industry and regulatory practices.

She explained that REV will be critical to ensuring that energy in New York remains reliable, affordable, and clean in the coming years. The energy industry is in transition as a result of technological innovation and the increasing competitiveness of renewable energy resources, combined with aging infrastructure, extreme weather events, and a growing need for system security and resiliency. These issues are all leading to significant changes in how electricity is produced, managed, and consumed. New York needs to make changes to ensure that these trends benefit the state's citizens, whose lives are so directly affected by how electricity is manufactured, distributed, and managed. The question before the Commission is whether there is a better way to provide energy services to consumers at a lower cost and in a cleaner manner, so that all consumers can benefit from a twenty-first-century power grid.

The REV initiative will lead to regulatory changes that can promote more efficient use of energy; deeper penetration of renewable energy resources such as wind and solar; and wider deployment of distributed energy resources such as microgrids, on-site power supplies, and storage. The initiative will also promote greater use of advanced energy management products to enhance demand elasticity and efficiencies. These changes, in turn, will empower consumers by allowing them more choice in how they manage and consume electricity.

Commissioner Acampora remarked that upgrading New York's aging infrastructure will be expensive. There is financial pressure on consumers' electricity bills, and improved system-wide efficiency is needed to support effective management of the total energy bill.

The Commissioner described two tracks within REV. Track 1 focuses on consumer engagement and education, which is of critical importance, particularly to ensuring that low-income consumers are not left behind. Consumers are ready to change, if they are given understandable, relatable information about clean energy, demand response, energy efficiency, and consumer choice. As part of Track 1, Distributed System Platform Providers will modernize the distribution system so that it is flexible for new energy products. This will involve creating frameworks to enable resource providers to monetize and provide value behind the meter. Track 2 will focus on regulatory rate design and rate making, and it will include efforts related to a clean energy funding strategy and revenue decoupling, among other areas. Although Track 2 will begin six months after Track 1, the success of Track 2 is essential to support Track 1.

She stated that one of the driving forces behind REV is the desire and need to lower peak demand. Today's electricity rates are very inefficient and are designed to meet peak demand. Thus, managing peak demand is the single most effective way to manage rates, because reduced peak demand will lead to cost savings for both utilities and consumers. She encouraged individuals to get involved in the REV process.

Vision: Capabilities and Functions of the Future Grid

Becky Harrison introduced the large group Visioning Exercise, asking participants to consider the capabilities and functions of the future grid starting with a "blank sheet of paper." This brief exercise was not intended to produce a consensus; instead, it provided participants with an opportunity to brainstorm in order to expand their thinking and envision the grid without the constraints imposed by the legacy infrastructure and business models. The exercise informed and stimulated conversation in the breakout group discussions that followed.

Elements of the Future Grid
Brainstorming Ideas from Workshop Participants

Role of the Grid – *Participants were asked to define the role of the future grid.*

- Ultimate enabler.
- Monetizes poles and wires—put everything else on top because that is where value is added.
- Optimize carbon cycle of other generation.
- Accounts for social justice issues.
- Why would there be a grid at all? It wouldn't exist.
- DC versus AC.

Characteristics of the Grid – *Participants were asked to define what the future grid will look like.*

- Would a grid even exist? What benefits would an interconnected grid provide?
  - Islanding.
  - Interconnectivity creates value for social justice and carbon reduction.
  - "Gated energy communities" in which residents self-select energy options. This could challenge interconnectivity.
  - People expect interconnectivity.
- Energy districts that compete for consumers.
- A trend toward distributed technology: microgrids, products, and services that consumers want.
- More diverse than today—some areas will have solar, others will have natural gas. "Roll your own."
- Ubiquitous and/or universal coverage, providing public benefit. Bubbles of generation with design based on the context of the situation. There will be diversified solutions. There is the question of how to share costs across bubbles for social justice needs.
- Removing carbon as quickly as possible is a priority; zero carbon generation deployed at a massive scale (distributed and utility scale), distributed and balanced over large areas.
- Big "pipes" with everything connected. There will be a centralized portion, but overall the system will be very decentralized.
- Water usage and generation are important issues—bigger than carbon in some regions.
- Reconcile the issue of who pays for what, with a future grid featuring many different elements that may be connected.
- Widespread growth in distributed solar generation has shown that consumers want a box in their backyard that does it all (provides power, is clean, etc.).
- There will be a lot of self-selecting. Interconnectivity means that a consumer takes his neighbor's baggage, too. In the future, consumers will tie themselves to the network that speaks to them and their demands (e.g., environmental quality and social justice).
- Social justice will be taken into account—there will be some level of free electric service.
  - New rate structure (university customer versus single mother cost comparison).
- The value proposition of the grid is in the connectivity. It allows carbon reduction and social

justice**.**

- Evolution in the concept of value provided.
- Carbon reduction, energy security, affordability, and a consumer-driven process are important in a European Union context; sometimes the United States forgets about affordability and a consumer-driven process.
- Consumers are diverse—industry thinks it knows what consumers want, but they are not all the same.
  - Defining who the consumers are is important.
- Giving consumers access to data will be important (e.g., via iPhone apps).
- When sophisticated consumers self-generate, what happens to the others?
- The grid will be driven from the edge inward; it will be consumer driven.
  - Consumers need to be educated if they are going to be relied upon.
- When originally deployed, the electric grid was an enabler of other technologies (e.g., dishwashers).
- Must be aware of preceding models (do not want to re-silo).
- Incorporate externalities (energy, water, land use, social issues) into the design of the future grid.
- Allowing consumers to self-select will, in turn, have them select for those who cannot select. "Clean skimming" will have the effect of selecting for everyone else.
- If we have a blank sheet, consumers would be motivated to generate and plug and play.
- Consumers will be incentivized to leverage their assets and behaviors to assist in the optimization of the system, including optimizing the grid.
- With today's grid, necessary behavior/lifestyle changes can be achieved through consumer education.
- With distributed prices falling and central generation costs rising (or when electricity prices from utilities become prohibitive/too costly), those consumers who can afford to buy distributed energy sources, such as PV, will leave central generation.
  - There is the question of how to maintain the current central grid and enable distributed services/generation bubbles.
- Industry should look at the copper phone network analogy. How is that being paid for now? Industry does not want to see the grid become the copper phone network. How does industry enable the bubbles and keep the value in the grid? Can industry afford to do this?
- In many household budgets, electricity is a small part (compared to other costs). These consumers do not want to deal with electricity; they just want it to be there when they flip the switch.
- As the central system becomes antiquated, at what point does distributed generation just make sense?

Consumers – *Participants were asked to discuss consumers of the future grid.*

- It is difficult to talk about consumers as a single entity.
  - Policy is the proxy to address consumer needs; consumer interaction is critical, but policy is a driver.
- Enable price signals to flow and see what the market will do.

Transition-Related Issues – *Participants were asked to identify issues that must be considered as the transition to the future grid occurs.*

- The modernized grid leverages value across the system. The grid is critical to the future. It increases the value of resources wherever they are. Prices will go up in isolated markets.
- It will be important to define the core set of functionalities of the future grid, what the platform represents, and what the legacy system must provide. How will it be paid for?

Scenario 1: Balancing Supply and Demand as Grid Complexity Grows

Description of the Scenario

This scenario is characterized by:

- On the consumer side: increased distributed generation and storage at the residential level as well as larger distribution-size renewables; for example, microgrids, community renewable projects, smarter home energy management systems, smart appliances, and electric vehicle (EV) charging.
- On the transmission side: increasing penetration of non-dispatchable generation sources ("large wind"), more utility-scale renewables, and utility-scale energy storage.
- Increased use of consumer devices or generation to balance the system or provide ancillary services.
- Increased dependence on smaller generation versus large base load generation or peaking plants to manage the system.

Together, these characteristics suggest a need for:

- Managing two-way power flows for the distribution grid, not only the transmission grid.
- Enhanced balancing capabilities to balance more complex supply and demand options. Greater dependence on "edge-of-the-grid" devices.
- Greater interaction between the distribution and transmission grids and grid operators to optimize the balancing of supply and demand.
- Enhanced weather forecasting methods.

Path Forward: Articulating the Vision

The following summarizes the Scenario 1 breakout session discussions. This content was generated entirely by participants and reflects their vision for the end state of the future electricity grid under the Scenario 1 assumptions. The participants also recognized that there will be a transition period before the end state is reached. The bolded bulleted text was provided by participants during report out presentations and has been minimally edited. The supporting bulleted text was drawn from workshop discussions.

Description of the Group's Future Grid, Based on the Scenario

- **The grid will leverage two-way, predictable power flows across the system.** Two-way communication, visibility, and predictability will be important.
- **The grid will be designed from a holistic systems approach.** Distributed levels of information that work together to form a holistic approach will be needed. There will be different levels of responsibility and different levels of information throughout the system; not everyone will need to have all the information or models, but the exchange of information will be needed.
- **The grid will leverage a portfolio of distributed devices with control functionality.**
- **The grid will be both bigger and smaller from an operational perspective.** Favorable supply-side options will be leveraged regionally. Utilities will integrate operations to mitigate risk. These entities will offer a more diverse suite of services. Control centers will have greater visibility

throughout the system. The increasing system complexity will be made simple through the application of sophisticated algorithms.

New Capabilities and Functions

- **Algorithms will be pushed to data, not vice versa, in real time to create big models and big analysis. This shift will enable the development of more effective, holistic models.** The current model is pushing data around the system. A new, automated paradigm is needed that pushes the algorithms to give the operators control.
- **The exchange of information vertically will be automated, enabled, optimized, and regulated by the development of interface standards.** Interface standards need to balance supply and demand with freedom and responsibility. Participants in the system must understand what they need from other entities and what they will provide if they are going to participate in the system. Behavioral/interface standards regarding data will need to be created. With the consolidation of management authorities and the rise of data analytics, information management tools will be used from top to bottom. There will be a diminishing return to having the "Wizard of Oz" controlling everything, because of the volume of data and then having to parse and act on that data. There will have to be some decentralization of the data and control in order for it to be managed and utilized.
- **Models used in systems planning and operations will be self-correcting—i.e., wiki models.** A model with multiple independent sources will fix itself; a self-healing model and a self-healing system are desired. Currently, lots of models receive lots of mistakes as inputs, and there is no way to determine when something is wrong.

Differences for the Operations Centers

Transmission:

- **Transmission and distributed systems will interface with greater granularity.** The boundaries between distribution and transmission will blur from an operational perspective; small generators will be added to the system that the transmission operator will have to balance. There will be consolidation of balancing authorities, resulting in larger control areas. There is the question of how regional decision making will be reconciled in this blurred context.
- **Information will be exchanged with distribution system operators in close to real time.** Operations will blur. This will involve getting notice of efficiency at the distribution level to plug in to transmission planning. There will also be a need for real-time management of resources—this is a gap today.

Distribution:

- **Tools and software will exist to operate the distribution system in an optimized cost environment with more distributed assets in close to real time; visibility down and through the system will enable control at the edge.** With more distributed assets, the grid will need to be managed out to end devices. Greater and faster visibility will allow management closer to the edge, which will allow for optimization. Distribution management systems will be needed that allow better management with increased distributed assets.
- **The integration and synchronization of distributed generation and microgrids will become key components of distribution system operations.** Seamless transitions and interfaces will be needed. The larger grid and microgrids both have value; the future grid will leverage the value of both.

Business Models and Investments

Financial/Business Model Changes:

- **Performance-based market models must be built on constructs where growth is not the only factor that drives revenue. This shift would incentivize innovation and optimize service delivery.** Revenue schemes will need to be designed to leverage benefits to the environment, consumers, efficiency, and other factors. Efficiency improvements should be incentivized.
- **Investment in technology with new functionality will enable additional benefits to be realized; new business models will monetize these benefits.** Integrating renewables into the grid will require investments to ensure that everything works together. Regulators must do what is necessary to ensure that the utilities are compensated appropriately.
- **In addition to traditional power delivery, utilities will provide market-based consumer services, including the following:**
  - Universal services fee—transport fees.
  - Additional connection charges.
  - Bundled services and/or a la carte services. Distribution service providers should be able to bundle services. Utilities should be allowed to offer the services in which they already excel.
  - Distributed generation.
  - Battery backup. Utilities should be allowed to compete directly against battery storage.
  - Microgrid servicing.
  - Power quality.
  - Redundancy services.
  - Premium power services.
  - A highway for consumers to sell their excess power.

New Investment/Funding Requirements:

- **Performance-based incentives and penalties.** The paradigm must be shifted so that the benefits from investments other than costs are considered. Compensation should be tied to performance in order to incentivize utilities to do the right thing, and the concept of "performance" will need to be articulated. It involves reliability, choices for consumers who want to use the platform, and a certain level of capability that only a utility can provide. If performance is the basis of the new business model, both positive and negative incentives associated with the performance metrics will need to be established.

Ideas on Social Justice

Participants shared ideas on social justice and the future grid:

- A publicly funded third party could subsidize fundamental, necessary services.
- Renewable energy credits: money could be deposited into a fund and then redistributed based on policy directives.
- Performance-based penalties could go toward a fund that supports a suite of basic services that benefit the social good.

Regulatory and Policy Barriers and Opportunities

Barriers:

- **Existing rate structures do not incentivize a shift in business models or innovation.**
- **Generation ownership rules constrain the deployment of new technologies such as microgrids and energy storage.**
- **Lack of clarity (from both regulators and consumers) regarding cost components.** The components that make up electricity bills must be clear. It needs to be clearly communicated to consumers which services they are receiving and the cost of those services. Consumers need to be educated about the future needs of the infrastructure and why they are necessary (i.e., their value).
- **Data privacy concerns regarding information availability.**

Opportunities:

- **Incentivize efficiency improvements.** Incentives must be created in order to drive investments in new technologies.
- **Investment-based incentive structures should apply penalties for underperformance** as well as rewards for superior performance.
- **Revenue decoupling.** Revenue decoupling includes valuing unregulated services at market rates and better managing ongoing costs. It will need to be determined what value consumers put on the service provided, including storage. The ability to calculate costs at all points along the system will be needed.

Message to Policy Makers

Participants were asked what message(s) they would give to policy makers for them to consider when developing future policies so that electricity delivery is not adversely impacted:

- **Enable change by helping to create a transparent framework that aligns benefits, costs, services, and the business model to encourage innovation and investment.** There needs to be a framework for the whole value of the investment. Different market rules create inefficiencies, so there will need to be tight coordination of rules between the boundaries. There is consensus that the status quo cannot remain. Policy makers are in the best position to articulate the necessity of change for the public benefit. Policy makers should allow utilities to take on additional risk. Consumers should be involved during the whole process.

Necessary Actions

Participants identified the following actions that should be undertaken in order to evolve to a cost-effective, reliable, and resilient grid of the future:

- **Apply performance-based incentive structures that include penalties for underperformance** and rewards for superior performance. Performance metrics will be needed.
- **Decouple revenue constructs and align incentives to encourage investment in new technologies and monetize performance-based services, including the following:**
    - Environmental impact.
    - Resilience.
    - Reliability.
    - Restoration time.

  - Energy efficiency and efficiency of operations.
  - Consumer experience.
  - Security.
  - Affordability.
- **Define grid services fees (basic and a la carte).**

Scenario 2: Involving Customers and Their Loads in Grid Operations and Planning for Empowered Customers

Description of the Scenario

This scenario is characterized by:

- Retail availability of smart devices and consumer expectations that devices will "plug and play" with grid operations.
- Greater consumer control over, and ability to react to, the price of energy. A greater number of available service options.
- Increased availability and prevalence of smart devices, along with EVs that can respond to signals from the grid operator. Devices are capable of two-way communication with the grid.
- A significant increase in local (edge-of-grid) clean generation (such as rooftop solar), electrified transportation, and storage to meet individual consumer (residential, commercial, and industrial) needs and expectations. Ancillary services being met through the control of these devices. An imbalance between reduced/falling overall demand and higher peak demand.
- Technological innovations, new market structures, changing consumer expectations, and policies that foster consumer empowerment.
- Consumers being more informed about their options, in part due to social media.
- Rising electricity prices and falling distributed generation costs, which lead consumers to more closely consider their options.
- Increased interest in energy efficiency.
- Consumer behavior changes as a result of education, resulting in lower electricity demand.
- Policies that are playing a part in grid modernization, including net metering rules.

Together, these characteristics suggest a need for:

- The ability to incorporate complex economics with complex physical integration.
- An architecture and design that can optimize the loads and their response in a way that maximizes efficiency and minimizes costs.
- Ways to synchronize the operation of potentially millions of devices at the edge of the grid.
- Ways for the grid to adapt when edge-of-grid devices are scaled from hundreds to tens of thousands. Consumers are unaware how their own choices impact larger grid operations; when these individual decisions are scaled to hundreds or thousands of devices, the impact to grid operations will be tremendous.
- A "transactive energy" concept, representing the complex interaction between physics and economics at the edge of the grid.
- Recognition that consumers now have choices for meeting their specific electric power needs.
- A better understanding of consumers' needs, desires, and choices.
- A better understanding of how increasing consumer expectations and choices impact the distribution grid and the transmission grid.
- Consideration that by 2030, consumers will have a profound impact on how the energy value chain is built and operated.

Path Forward: Articulating the Vision

The following summarizes the Scenario 2 breakout session discussions. This content was generated entirely by participants and reflects their vision for the end state of the future electricity grid under the Scenario 2 assumptions. The participants also recognized that there will be a transition period before the end state is reached. The bolded bulleted text was provided by participants during report out presentations and has been minimally edited. The supporting bulleted text was drawn from workshop discussions.

Description of the Group's Future Grid, Based on the Scenario

- **Increased demand response, EVs, distributed generation, microgrid, and transactive energy.** People will not simply consume electricity; people will be "prosumers"—both consuming and selling energy back to the grid. Transactive energy (a method for using price signals to manage transactions with consumers), which is being experienced now through demand response, will increase. The "Internet of things" will become more prominent. PVs will also become more common. Peak load is already shifting to 8 p.m. Time-of-use pricing is already being used to accommodate this shift.
- **New, increasingly complex range of consumers.** Consumer segmentation and needs will evolve. There will be an increasing percentage of prosumers. Consumers will range from advanced to very basic, and they will have a range of needs. Consumers are willing to help with the transition to the future grid—they have proven that they are willing and motivated to use new technology, *if it is easy*. Outreach and education will be important to ensure that consumers know of all of their options, such as taking advantage of time-of-use pricing. For certain populations of consumers, new technologies do not have much meaning—despite a general focus on technologies—and these populations will need to be accommodated. Operators and utilities will need to provide consumers with the capabilities that make it compelling for them to participate. Security and privacy will be very important to consumers.
- **New, increasingly complex grid operations.** Large penetrations of distributed generation will increase the complexity of grid operations significantly.
- **Distribution grid operators could act as retailers and wholesalers.**
- **The risk that increased costs will force a large percentage of consumers from the grid.** If electricity costs increase too much and distributed generation costs fall, many consumers may decide to generate their own electricity rather than staying connected to the grid.
- **Two-way intelligent networks with more real-time information and lower latency.**
- **The lines between transmission and distribution will blur.** Complexity will be greater at the distribution level.
- **Outcome-based rate-making process.** Financial incentives for utilities should be given based on achieving certain outcomes.

New Capabilities and Functions

- **Measure and verify data at a much more granular level, leading to truly cost-based rates.** Rates should be disaggregated and broken down into their components. Rates should be based on how much it really costs for consumer to be connected.
- **More insight into the behavior of the grid—"Big Data."** This will involve predictive analytics for demand response, load dispatch, and grid operations. The increased predictive analytics will involve weather, and there will be increased intelligence regarding demand response.

- **Distribution operators and third parties will provide more apps to their consumers.**
- **Inertial energy storage will go away in favor of battery storage.** This shift will have policy considerations. Policy should guide how storage is used by consumers and how consumers are rewarded for providing energy back when needed. To be beneficial to utilities, storage will need to be charged and discharged to match distribution or system peak. Currently, consumers are not rewarded that way. Additionally, storage should also be charging when there is an excess of solar or at other times when the grid is least stretched, as opposed to whenever the consumer wants. Policy should get the cost right regarding how people pay and are compensated so storage can be used to decrease the cost of running the grid.
- **More service based than commodity based.**
- **Clearer delineation of consumers' obligations to the grid as well as utilities' obligations to consumers.**
- **Dealing with local jurisdictions on zoning, etc.**
- **Consumer protections around new technologies, such as microgrids.**

Differences for the Operations Centers

Transmission:

- **Visibility to the meter level of generation (i.e., the end-of-line).**
- **Lower latency of communications between end points (machine-to-machine interaction).** An increase in machine-to-machine interaction will also lead to greater scalability.
- **Synchrophasors.**

Distribution:

- **Increased sensing and control equipment will be integrated throughout the distribution system.** This will provide for better overall power quality and control.

Transmission and Distribution:

- **Greater visualization tools for processing the increased information provided by data; greater intelligent automation.** Transparency, automation, and enabling technologies will be needed.
- **More diverse resources will be bidding into the system.**
- **Current workforce skillset cannot manage operations.** The workforce must have a different skillset now than what was needed 15 years ago.
- **The grid of the future runs the risk of being late in providing solutions.**
- **Operators need to have interoperability to provide visualization of data across domain boundaries in real time.** The data must be understandable and able to be formatted.
- **Greater use of existing data; stranded data.**
- **Systemic, methodical process—vision is implemented and rolled out differently depending on location and needs (risk based).**

Business Models and Investments

Financial/Business Model Changes:

- **Market rules.** Market rules will need to enable a wider range of products/services and providers, including nonregulated providers. Products/services will include apps, packaging of data, ancillary services/reactive energy/regulation services, and third-party storage providers.

- **Utilities are intelligent network managers—numerous markets for numerous products.** Utilities should be paid for network services rather than just for energy.
- **The business model should drive rate, design, and value.** How value is defined, captured, and compensated will need to be determined.
- **Utilities and/or third parties providing consumer meter-side products and services.** The market will expand to inside the consumer's home (e.g., home energy management and bundling). There will be many new entities depending on the market/market rules. The market will go beyond the traditional meter.

New Investment/Funding Requirements:

- **Investments in greater telecommunications and system control requirements.**
- **Potential public-private funds (e.g., utility and university researchers) coming together to move markets.**
- **Develop a model that allows measurement of smart grid reliability investment versus traditional investments to get based value.**
- **Need to think about the next generation of research and development (no longer reliant on American Recovery and Reinvestment Act funding).** There needs to be a continuous process of funding for innovation (do not assume federal funding).
- **Much shorter payback period for funding/investment requirements (much shorter time frame for paradigm changes now).** Investors want a better guarantee of return on investment. Test beds can be used to prove hypotheses (e.g., grid-level storage, PVs, and smaller scale).
- **Utilities need flexibility to do things differently (e.g., to become a service provider).** Utilities can help provide and/or run microgrids.
- **Expand growth opportunities for utilities.**
- **Balance decrease in wholesale cost of power.**
- **Rate designs will change (e.g., variable versus fixed fee); do not assume 100% ratepayer funded.** There is the question of what can be funded by ratepayers and what can be funded by new revenue streams. Some funding will be ratepayer based, and some revenue will be generated from optional services for which consumers choose to pay. Stakeholders need to remember that consumers are sometimes willing to pay more for quality. Television used to be free, but now consumers pay for cable. Phone service is more expensive now, but cell phones provide additional value. Some consumers will be willing to pay for services that they use.

Discussion on Managing Expectations

Electricity providers will have to manage consumers' expectations. Some consumers have unrealistic expectations about the future grid. They may expect to be able to access their own generation as much as desired, and to connect to the grid as a backup for free. Distributed generation may not always meet consumers' needs without a storage breakthrough. There will also be a cost component. The individual facilities fee may go up, but usage will go down. Consumers will need to pay for reliability and backup to stabilize frequency and voltage. If electricity providers do not set expectations upfront, consumers will think that the reliability offered by the grid will be free because currently there is no charge for this.

Regulatory and Policy Barriers and Opportunities

Barriers:

- **Lack of time-differentiated rates.** Traditionally, fixed rates have been utilized.
- **Regulatory cycles are shorter than investment cycles.**
- **Technology is moving quicker than regulatory cycles.** Technology asset life is shorter than regulatory asset life. These need to be reconciled.
- **Least-cost rates need to give way to the incorporation of values and externalities (e.g., cost, demand requirements, and reliability investments).** This involves moving from a commodity-based system to a service-based system. There is the question of whether the current reliability standards are adequate; in particular, reliability may have greater value today.
- **Costs and value are not being captured.** Values and costs are not always explicitly defined.
- **Political barriers.** The reality of the political environment must be considered—only so much is realistic.
- **Outmoded pricing mechanisms (e.g., fixed versus variable class).** There will be a move to something more workable and sustainable—it will involve the recovery of the cost of the grid and paying for the value of the resource. Current rate classes do not accurately capture costs and are not sending true economic signals.
- **Traditional monopoly of the utility on the wire.** This includes zoning laws, eminent domain, and consumer protections.
- **Need to redefine what is considered basic service.**

Opportunities:

- **Incentivizing innovation (least-cost, risk-averse approaches do not yield innovation).** Performance and value creation should be rewarded instead of capital investment.
    - Managing capital and operating expenses to the best outcome should be rewarded. There should be a move away from capital expenses to total expenses and other performance-based methods. Consumer rates should include protection against revenue decline. There should be clear and established intermediate and long-term goals, as well as metrics to measure outcomes and to direct alignment with capital expenses and outcomes with measured results. In addition, innovation should be aligned with those goals. There should also be utility incentives for patents and new ideas.
    - Commissions could allow funding and best practices to be implemented/pursued. Incentives should be tied to consumer value. A utility consortium with national laboratories/researchers could facilitate the sharing of resources for greater innovation. There are policy opportunities regarding incentives for utilities to develop best practices, fund test beds, and pursue R&D.
- **Redefine aspects of new service-driven network provider to establish what will be part of the utility monopoly and what will be controlled by market forces.** It will need to be determined what services are part of the natural monopoly of the utility, and exactly where the distinction is between regulated and unregulated entities.
- **Allow rate experimentation.** For example, this could involve voluntary, opt-in, consumer choice rate considerations.
- **Revisit established asset lives (particularly for new technologies).**
- **Improve communication among all stakeholders and change the dialogue.**

- **Change rate proceedings (doing regulation at the speed of business).** Shift from alternative regulation to multi-year plans filed by utilities. Rates should be based on these plans, which have a longer time horizon, are forward looking, use metrics-based outcomes, and use the Revenue = Incentives + Innovation + Outputs (RIIO) model.

Message to Policy Makers

Participants were asked what message(s) they would give to policy makers for them to consider when developing future policies so that electricity delivery is not adversely impacted:

- **The cost of storage and PV could go below the cost of utility service.**
- **No matter how much innovation occurs, some will be left behind and will need to be protected.**
- **Recognizing the value of the grid as the enabler of the future.**
- **Cannot facilitate a digital grid with an analog regulatory system.**
- **Utilize the national laboratories more.**
- **Technology wins.**
- **Remember that consumers are not a monolith.**
- **Arrogant to think you know what consumers want.**
- **No free lunch; everything has a cost, so make sure consumers see the benefits.**
- **Look at the telecom industry as a parallel.**

Necessary Actions

Participants identified the following actions that should be undertaken in order to evolve to a cost-effective, reliable, and resilient grid of the future:

- **Change the cost recovery model and ensure accountability.** There will need to be a transition toward performance-based rates. The rate structure should be changed so that actual costs are disaggregated. Policy objectives should be aligned with utility business models and investments. It will be necessary to look across the integrated system to maximize value (e.g., break down silos) and fully recognize the role the grid plays. The economies of net metering should be limited to time-of-use rather than arbitrarily defined rate classes.
- **Incentivize R&D.** Reliability should be kept pure and sacred; it should not be confused with other constraints. Regulators should fund and build an intelligent, advanced digital network (communications and intelligence). Regulators, policy makers, and planners should plan for disruptive elements (e.g., storage, PVs, vehicle to home, very-large-scale events, and other "killer" apps) so that utilities and the market can adapt. There is the question of what will happen when such technologies hit their new market segments.
- **Make the physics of the electric system a basic knowledge requirement for regulators; a greater understanding of the grid is needed.** For regulators to be able to understand the evolution of the electric system and the need to modernize the grid, they need a deeper understanding of how the system works. It is no longer enough just to understand traditional rate making.

Scenario 3. Higher Local Reliability through Multi-Customer Microgrids

Description of the Scenario

This scenario is characterized by:

- Microgrids that are widely deployed to meet a variety of customer needs: increased reliability, greener generation, higher power quality, etc.
- Increased sophistication of these microgrids, with a mature market by 2020.
- Microgrids becoming a dominant force in grid operations in 2030 and beyond.
- Microgrids serving a single customer or multiple customers.
- Microgrids that utilize larger grid infrastructure but are also able to operate independently when necessary.
- A possible disruptive or destabilizing impact of microgrids on the traditional grid (shrinking number of ratepayers to support grid infrastructure, rising costs per ratepayer).

Together, these characteristics suggest a need for:

- Appropriate grid interface standards to allow for optimal operation of the grid, the microgrid(s), and both together.
- Consideration for how these microgrids will impact infrastructure investment for the larger grid.

Path Forward: Articulating the Vision

The following summarizes the Scenario 3 breakout session discussions. This content was generated entirely by participants and reflects their vision for the end state of the future electricity grid under the Scenario 3 assumptions. The participants also recognized that there will be a transition period before the end state is reached. The bolded bulleted text was provided by participants during report out presentations and has been minimally edited. The supporting bulleted text was drawn from workshop discussions.

Description of the Group's Future Grid, Based on the Scenario

- **Centralized-decentralized hybrid.** There will not be one standard or infrastructure; central generation and microgrids/distributed generation will complement each other. The central grid should be made smarter with greater control on distribution, in a manner similar to an ISO role.
- **Microgrid as a backup/storage.** Excess energy from the microgrid can serve as a backup or storage for the central grid; the level of backup/storage provided will need to be determined and communicated to the utility. Consensus on coordination between microgrids will be necessary.
- **The process to get to the future state is critical—it determines outcomes and outputs.** There needs to be a process to transition from today's reality to a state where more microgrids exist. How microgrids and the larger grid interact and operate together will need to be determined. This will require a shift from traditional rate cases. External impacts—which were not considered in earlier cost-benefit analyses—will need to be considered going forward.
- **Least-cost approach compared with highest-value (externalities) approach.** The least-cost approach needs to be weighed against the highest-value approach. For example, in Europe, variable-speed drives have been adopted for hot water heaters because they provide

efficiencies that present greater value in the long term. In contrast, the United States has relied on a least-cost approach with hot water heaters that stay on all day, which is less efficient in the long term. Consumers need to be incentivized to embrace energy efficiency.
- **The transition cannot just be driven by utilities; different stakeholders' priorities must be considered.** A broader set of stakeholders should be included in the conversation about grid development, including about rate structures. The utility franchise monopoly is over, and new technologies will enable price signals.
- **Need to incorporate diversity of consumers, resources, and geography.** The identification of high-priority assets needs to move beyond critical infrastructure and include diversity of loads (which depends on time scale).
- **Thinking outside the box about who is going to pay for all of the new infrastructure.** Insurance companies and hedge funds might consider investing in infrastructure improvements, including microgrids, to help avoid the impacts of events such as Hurricane Sandy. Consumers are already paying an insurance premium to offset costs from these events.
- **Planning of the grid has to be more open and transparent.** Planning needs to be open to all stakeholders in a community. Additionally, who can be involved in microgrid development and use will have to be established. Social justice issues will need to be addressed.

New Capabilities and Functions

- **System that optimizes dynamic operation (real-time/automated).** Microgrid load has to be managed, and constraints for managing the microgrid and its interaction with the larger grid will have to be established. The microgrid will have to operate within these limits.
- **Scattered control and operational "brains" (distributed intelligence).** Because a microgrid can serve as an independent energy resource capable of shifting and shedding loads, its "brains" will not be in a central location but instead scattered along the body. There will be distributed intelligence that considers verticals; that is, how performing an operation may impact other aspects that are within the utility's control or responsibility.
- **Vertical-horizontal integration.** Operations within an organization's/utility's (vertical) domain are expected to collaborate with other (horizontal) entities that also interact with the grid (e.g., microgrids).
- **Decentralized instantaneous process led by technology.** Technology will be the driver for the grid; storage will be the next big trigger for change. Storage will be a major disruptive technology in terms of changing how the grid functions.
- **New safety protocols.** Protocols and standards need to be put in place surrounding microgrid interconnections to ensure the safety of grid personnel working on the lines.
- **Who is responsible when the power goes out?** Regarding microgrid ownership, it will need to be determined who—the utility or the microgrid owner—will be responsible for restoring service. The issue of obligation to serve will need to be defined.
- **A whole new generation of experts is needed to operate and maintain microgrids.**
- **Diversity of reliability models; "critical load" must be defined.** Critical loads must be defined so that they can be met during an outage event either by microgrids or by drawing from the central grid. Reliability is the top issue—it is an issue to address over the next 20 years. The level of reliability and cost must be considered (what needs to be on all of the time). It also needs to be determined whose power should be turned off first, and who decides what to turn off. There is also the question of how much reliability/class of service will be desired.

Differences for the Operations Centers

- **New class of control rooms for transmission and distribution market coordination; distribution will be the heart of the future grid.** Utilities will play the coordination role in the decentralized grid system. There will be increased accountability for managing the system with reliability as the priority. Utilities will be the enabler of energy market transactions. It will need to be determined whether the coordination between wholesale and retail markets will be handled by a single entity (e.g., an ISO), or whether a market coordination function will be added at the distribution level. New York State's REV initiative is proposing different distribution system operators under a single transmission operator (NYISO).

Transmission:

- **Dynamic system prediction/real-time power to supply balance with short-term forecasting.**
- **More integrated coordination between transmission and distribution.** The distribution system operator will possibly be capable of acting as a transmission system operator, and vice versa. Transmission and distribution zones will merge, and there will be permeation.

Distribution:

- **Multi-layer optimization and decision-process automation.** This should occur at the consumer level because consumers are always a consideration; providing this to consumers allows them to prioritize. Microgrids allow for the facilitation of multi-layer optimization and decision-process automation. Geographic diversity must also be considered. It can be customized at distribution/transmission levels.
- **High-frequency multi-party interaction and integration.** With microgrids interconnecting with the electric system, they will impact both distribution and transmission systems. Interaction will be segmented out between layers and energy needs may become more difficult to predict with interconnected microgrids. An entity (e.g., a distribution system operator) will need to be created that interacts with ISOs/transmission. However, this process does not necessarily involve two neat boxes with transmission and distribution.
- **New class of service offering.** Microgrids will be a new service offering. There will need to be a discussion about whether they are private or run by utilities, with considerations including regulatory barriers. It will need to be decided what the critical loads are within a microgrid and how these are serviced.

Business Models and Investments

Financial/Business Model Changes:

- **Rate structure that compensates for capacity structure.** This will involve compensation for idle assets (e.g., backup microgrids). Also, it will need to include considerations for prosumers and the possibility of selling electricity back to the grid.
- **There will be more fixed charges.** This could include interconnection fees or backup fees. Currently, average distribution pricing is utilized. A move to fixed charges versus volumetric pricing could better incentivize conservation. There will need to be a move toward greater transparency in pricing.
- **New class of service-based pricing.** It will need to be determined to what extent this will be handled through regulated or market-based pricing.

- **There will be a new energy merchant function-based business model.** Possible models could include (1) the utility/consumer partnership model, with utilities as a project developer (e.g., shares savings model), and (2) the utility model, whereby utilities invest in assets and receive a rate of return.
- **Make distribution utilities more accountable for optimizing demand, integrating distributed resources, improving workforce and asset management, and improving reliability/resiliency.** Distribution utilities will have a newer, expanded role that will include microgrids. The business model will need to address these issues.
- **Performance-based pricing.** Performance-based pricing still envisions a utility with regulations. A business change might take the core function out of a Public Service Commission's (PSC's) jurisdiction and place it with the market, or it could have the utility define what it provides (e.g., data and consumer load). There are questions about the transactive role at the distribution level; specifically, about (1) selling to the ISO and distribution entity, and (2) finance markets that get paid a portion of transactions for enabling the function. These issues will need to be resolved.
- **Creating the right incentives/objectives for utilities.** Accountability might need to be increased for the already accountable parties (i.e., distribution owners/operators and transmission owners/operators) by pricing according to service. Consumers can customize the types of services they want. One of the most successful microgrids has a single consumer where things can be customized/optimized. However, there is the question of who consumers call about problems—the utility or microgrid service provider. This is related to the question of who has the obligation to serve.

New Investment/Funding Requirements:

- **Different ownership models and purpose models of the microgrid.** If a utility manages a microgrid, there would be considerations about how its model for managing that subset of consumers would differ from the model it employs with the central grid. With the traditional grid, there is a fixed cost spread out over a large number of consumers. Microgrids service fewer consumers. There is also the question of who services the microgrids; it will need to be determined who will bear the cost. Different states have different rules regarding generation ownership, which can hamper microgrid implementation. These issues will need to be addressed and defined. Some service areas are critical, and the costs for providing services to these areas might need to be socialized. If hospitals/fire departments have microgrids, it will need to be determined how costs are shared between different users.
- **There needs to be a move toward private ownership and operation, bringing private system efficiencies into the distribution side.** A U.S. Department of Defense study showed that privately owned assets are about 30% less expensive than public/utility owned assets. This is because utilities are cost-of-service-based, while the private sector seeks a big return. In New York, spinning off generation led to cost decreases. Some core services under a utility's control could be provided by non-regulated market entities.
- **Industry stakeholders will need to look at the overall system and how it is interconnected.** Without looking holistically and taking into account various consumer aspects, multiple microgrids might create divides between those who can pay for better service and those who cannot, which has happened with distributed computing.
- **Private investment and consumers pay back through the energy efficiency/energy savings.** A private organization could provide the initial funding for a microgrid, and consumers could pay the organization back through energy savings. For the most economical microgrids in the world,

where efficiencies help reduce bills, the energy savings pay for the microgrid. Regulatory subsidies could also possibly be considered.
- **Master limited partnerships (MLPs).** For microgrids, a preferred tax status (incentive) should be considered.

Regulatory and Policy Barriers and Opportunities

Barriers:

- **Franchising for multi-customer private microgrids.** Establishing a multi-customer microgrid is challenging because it involves distribution. In New York, non-public utility service cannot cross public roads. Regulations differ by state, but these types of microgrids usually need to get a franchise exception. This can be difficult in the current regulatory environment and is a barrier for microgrid development. The PSC is able to issue one-time exemptions to the microgrid owner allowing utility service to cross public roads; however, this process can be lengthy and creates uncertainty in the market for microgrid owners. In New York, microgrids require exemptions for specific projects/single consumers, and there are presently 25 single-customer microgrids in the state. By contrast, Massachusetts legislatively defines its energy districts, which could allow microgrids for multiple consumers.
- **Restriction of utility generation ownership.** Currently, no incentives exist for utilities to build microgrids. For example, in New York, even if microgrids are utility owned, because of current regulations, utilities would not have ownership of the generation; microgrid consumers are not currently allowed to sell excess generation back onto the grid. These issues will need to be addressed.
- **Interconnection agreements.** Private microgrids have to follow current interconnection agreements to connect to the grid. Connecting a microgrid to distribution does not require adhering to Federal Energy Regulatory Commission (FERC) rules; however, this depends on the amount of generation. Interconnection technical standards and rules for connecting will need to be developed.
- **Standby rates.**
- **Cost of technology.** The cost of microgrids is currently a barrier, but various aspects of the cost are beginning to decrease, such as the increasing cost effectiveness of solar power and batteries.
- **What entity is going to identify microgrid development opportunities? Utilities have no incentives.** Currently, utilities are the only entities with the data, knowledge of consumers, and perspective to know where locating a microgrid would be valuable, but they have no incentive to share that information with others. In addition, utilities are aware of weaknesses in distribution and could identify where microgrid interconnections may help, but they also have no incentive to share this information. Rather, utilities are incentivized to increase the rate base by building new capital. Building microgrids is not encouraged under this incentive structure.
- **Environmental, siting, and permitting constraints.** Location and fuel type regulatory considerations can also constrain microgrid development.
- **Lack of economic analysis capabilities within the regulatory bodies.** State Public Utility Commissions (PUCs) do not typically have the knowledge or resources to accurately analyze the benefits or capabilities of microgrids. New York and Connecticut had to hire outside consultants (e.g., Rocky Mountain Institute) to consider the impact of microgrids.
- **Interdependence on multiple commodity/regulatory bodies.** While state PUCs have jurisdiction over investor-owned utilities and in some states utility cooperatives, they have to regulate within the authority granted to them under state legislation/policy, and therefore there is a

question of what the law prescribes regarding regulating utilities. In New York, the state legislature has wide latitude in its authority. In Massachusetts, the state government has Green Communities, the Green Act, and an upcoming natural gas bill. Many opportunities may reside at state-level legislation/regulations, but RTOs cross multiple state jurisdictions.
- **Lack of homogeneous standards.**

Opportunities:

- **Change the law to allow for franchise flexibility.**
- **Replacing conventional distribution upgrades (e.g., feeders and substations).** This could involve substituting distributed generation for conventional distribution upgrades.
- **Leverage private-public partnerships.** Private capital should be leveraged in grid investments.
- **Incentive for cost avoidance.** There should be an incentive for cost avoidance (e.g., for building a less expensive microgrid rather than a feeder with its associated costs). This would facilitate optimizing the efficiency of existing assets.
- **U.S. Environmental Protection Agency (EPA) greenhouse gas regulation.** The pending EPA 111D proposal for greenhouse gas regulation to reduce carbon emissions could incentivize microgrids because it could require the closure of coal/fossil generation plants and encourage the development of more microgrids that have cleaner generation sources.
- **Opportunity for consumers to act on their own cost-benefit priorities.** Consumers can invest in microgrids that meet their specific cost or benefit priorities rather than being subject to what the utility installs. Traditionally, utilities invest based on their cost-benefit equation, but consumers have their own needs. There is an opportunity for consumers to act upon their own needs or benefits.
- **State-driven initiatives under climate change goals.** The Connecticut Department of Energy and Environmental Protection, the NY Prize competition, Massachusetts' $50 million investment in climate change preparedness initiatives, and New Jersey's $200 million Energy Resilience Bank are examples of the relationship required with regulators to drive broader regulatory change, rather than just incentives.
- **Target funding into the part of the microgrid project that needs it the most (i.e., generation).** The most expensive part is generation, so there should be opportunities to funnel funding to generation. However, there needs to be flexibility with funding. In Connecticut and other states, incentives/funding can only be used for the interconnection of the microgrid to the utility grid.

Message to Policy Makers

Participants were asked what message(s) they would give to policy makers for them to consider when developing future policies so that electricity delivery adversely impacted:

- **Microgrid development presents an opportunity to show the world how the grid can evolve.** Microgrids provide an opportunity to demonstrate optimization of supply and demand for consumers, not just for utilities.
- **Physics is not driven by economics.** Policy makers need to understand that electricity delivery is constrained by the physics of the system, no matter the desired economic outcome. For example, when operating a control center, decisions are only made according to physics. Generation has been taken away from utilities, but it is the best tool to understand the physics of the system. Market forces were involved in the 2003 blackout.

- **A strong, integrated grid is required to support economic multi-customer microgrids.** The grid is also required to support other distributed resources. The distribution system is the heart of the future grid.
- **The past is not the possible future.** With the numerous changes taking place, the current method of operation cannot continue; the future will be different. One version of the future would be to rebuild the conventional grid, while another version would include finding another solution. Policy makers should think outside the box and consider externalities such as social justice, environmental concerns, and new actors. It will have to be determined if microgrids are part of this consideration. Policy makers tend to avoid change. There is a cost to not doing anything.

Necessary Actions

Participants identified the following actions that should be undertaken in order to evolve to a cost-effective, reliable, and resilient grid of the future:

- **Support the development of markets (e.g., distribution locational market prices), standards, and technology, as well as integration for dynamic grid operation and optimization.** R&D should be accelerated on data/load control management, although policy makers have concern that using the term "R&D" might represent moving too quickly. There should be technology integration/demonstration (there are currently 4,000 megawatts in place from microgrids worldwide). Dynamic grid distribution should be pursued.
- **Address legislative/regulatory/statutory certainties or changes at the federal, state, and local levels.** Policy makers may believe that they are already pursuing all of these efforts, except for perhaps the market element to encourage progress. New York's REV initiative involves creating a new market. Rule-making should also be considered.
- **Encourage and enable active stakeholder engagement.** Consumers and other stakeholders, including third-party innovators, should be fully engaged in the process of transforming the grid.
- **Ensure transparency in the process and path of grid evolution.** The focus should be not just on the vision, but also on the process and path. There should be open, transparent involvement by stakeholders in the process.

Scenario 4: Transitioning Central Generation to Clean Energy Sources—Large Wind, Large Solar, and Large Gas

Description of the Scenario

This scenario is characterized by:

- Increasingly affordable natural gas; rising use of natural gas.
- Lower costs for wind, solar, and other renewable generation technologies (as a result of incentives and increasing market demand).
- A majority of new generating capacity being supplied by renewables.
- New policies and regulations that are driving up the price of coal, oil, and nuclear.
- New participants in the market; impacts of changing wholesale prices on the profit margins of traditional and renewable power generators.
- New operating characteristics for the generation fleet.
- Possible strain from ramping and cycling.

Together, these characteristics suggest a need for:

- Increased infrastructure to transmit electricity from sites where it is produced to where it is used.
- Increased flexibility of the power system to manage the variability and uncertainty of generation from intermittent renewables.
- Strategies for addressing increasing penetration of non-dispatchable resources; curtailment.
- New alternatives to traditional planning processes to avoid overbuilding some asset capacity and underbuilding others.

Path Forward: Articulating the Vision

The following summarizes the Scenario 4 breakout session discussions. This content was generated entirely by participants and reflects their vision for the end state of the future electricity grid under the Scenario 4 assumptions. The participants also recognized that there will be a transition period before the end state is reached. The bolded bulleted text was provided by participants during report out presentations and has been minimally edited. The supporting bulleted text was drawn from workshop discussions.

Description of the Group's Future Grid, Based on the Scenario

- **A grid that is flexible to support the following:**
  - Public policy goals.
  - Large-scale storage.
  - Facilitation of regional power flows (across ISO regions).
  - DC transmission.
  - Less centralized generation; more distributed generation.
  - Transparency in forecasting, modeling, data, etc.

New Capabilities and Functions

- **Ability to island microgrids and resources to maintain essential services.**

- **Accommodates consumer choice.** Consumers want choice, and electricity providers must accommodate them.
- **Micro forecasting.** More generation will be closer to the load, so operation centers will need the ability to predict or forecast these new resources at the micro level (i.e., at the end device).
- **Provides several levels of service—base level is low cost and provided by central generation; higher level includes advanced services.** In some other countries, homes have a wire for their base load (e.g., refrigerator and phone) and a wire for their other loads. The second wire gets shut off during brown outs. The United States may need to pursue this level of involvement in the future. Consumers could have other means of accessing electricity during brown outs, such as buying into a microgrid.
- **Full-use grid utilization data; not just end-point consumer data.** Full-grid use data**—** such as loading at specific feeders**—**will be necessary, not just end-point consumer data.

Differences for the Operations Centers

Transmission:

- **Greater visibility for all resources on the transmission side—ability to "see" distributed resources.** This will include greater visibility to all resources on the transmission side, as well as the ability to "see" distributed resources. Visibility will be critical, for example, in predicting wind and solar power and consumers' behavior. ISOs do not currently have visibility into distributed generation.
- **Merging of distribution and transmission systems.** There will be more generation closer to the load; therefore, it will be necessary for transmission and distribution to communicate together.
- **Need the ability to forecast both production and demand of energy, and to use predictive analytics.** Operation centers will need the ability to predict or forecast the new resources, as well as the capability to forecast production and demand.
- **Must be able to integrate reactive power technology.** Deploying large amounts of distributed generation, such as PVs, requires a reactive power supply, and a control signal will be necessary (possibly with smart inverters) to provide communication between the grid and the PV system in order for it to provide reactive power versus real power.

Distribution:

- **Account for two-way power flow.** With two-way power flow on the system—versus the current one-way flow—protection and control for this two-way flow will be necessary.
- **Consumer data issues—security, ownership, analysis, and transmitting the data.** Energy providers will be collecting data from consumers; questions about who owns the data, what energy providers may do with it, how it can be secured, and how it can be anonymized will need to be addressed. Consumers will need to feel secure that their privacy is being protected.
- **Incorporate third-party service providers, including the value of utility data.** In addition to utilities having additional data, there will be third parties who want to provide services based on consumer data. The rules surrounding the use of consumer data will need to be resolved. With third parties offering other services, there will be new roles for the utility that will need to be defined.

Business Models and Investments

Financial/Business Model Changes:

- **Less reliance on subsidies.** Subsidies might not be available long term; therefore, they should not be included in long-term business models. Business models need to be sustainable without them.
- **Pricing that includes externalities.** Externalities, such as cost savings and social good, need to be included in pricing models.
- **Voltage regulation and fault current limiting—where does this service "live" in the business model?** As more distributed generation comes online, the grid will need to use capabilities such as reactive power and limiting fault currents. It must be determined who will pay for these capabilities. This is an example of an issue that the overall system as a whole must deal with, but that most people outside of the industry do not recognize/understand. The electric system involves more than just producing electricity. Sometimes energy providers turn on the generators just to produce reactive power. One option would be a fixed installation charge for these service capabilities.
- **Declining sales from distributed energy resources must be offset with fees (backup charges) to recover utilities' fixed costs.** As consumers leave the grid and generate their own power, but still want to stay connected to the grid for backup power, utilities will need a way to recover their infrastructure costs. These costs are currently included in electricity rates but would not be recovered from self-generators, although utilities would still have to incur these costs in order to provide backup services. Backup charges to stay connected could create needed revenue for the utility; they would basically be a service charge for users who have generation capabilities to use the power line in order to bring in or send out power.
- **Flexibility in setting tariffs for building new infrastructure, including differentiated pricing.** Anybody who puts in these facilities (all types of generation) should pay a value tariff for having that line put in to transmit power.
- **Does the infrastructure turn into the "highway" system owned by the public?** Utilities are good at building transmission lines to route power across the country. Projects have varying life expectancies. Also, the least-cost routing system should be considered.
- **Competitively bidding projects.**

New Investment/Funding Requirements:

- **Additional gas lines and new extra-high-voltage transmission lines to bring power from distant generation.** In the case of a large-scale renewable project, it will be important to find a way to finance transmission. Renewable resources are intermittent; therefore, dispatchable resources, such as a gas resource, will be needed to balance out the intermittency. In the future, it may be necessary to integrate wind and solar with other resources if there is no storage.
- **Regulated utilities must still get a guaranteed rate of return to offset the risk of investing in infrastructure.** Investor-owned utilities' (IOUs') investors will not assume increased risk without increased returns; this may also change which investors buy utility stock.

Regulatory and Policy Barriers and Opportunities

Barriers:

- **The link between profit and sales needs to be decoupled.** Rates need to be decoupled so that utilities are compensated for overall infrastructure investments, even when consumers power themselves.
- **Stranded assets.** Stranded assets were the biggest stumbling block with deregulation. That was dealt with on a one-time basis. In the future, there is the possibility of stranded assets if there is a lot of distributed generation. It will be necessary to determine what is needed in the wholesale market to accommodate leftover generation and the associated transmission lines in the new distributed world. In addition, utilities need to be encouraged to put in the infrastructure in order to obtain the data needed for future operations, but this could also lead to stranded assets. This issue will have to be addressed.
- **Accounting mechanism needs to be "modernized" to accommodate software and other high-tech investments.** In most cases, operations and maintenance (O&M) expenses are "pass-through" expenses. IOUs do not make a profit on O&M expenses and can actually lose money if the O&M expenses exceed the allowed pass-through amount between rate cases. Therefore, IOUs are not incentivized to improve efficiencies if doing so increases O&M expenses, even if this is the best solution. Because many innovative technology investments tend to have a significant O&M component, the current accounting mechanism must be addressed.
- **Federal and state jurisdictional issues.** Access to data can sometimes be difficult because of federal/state jurisdictional lines, which limits some entities' rights to certain data. For example, ISOs, which are regulated by FERC, have limited rights to access distribution-level data, which is regulated at the state level. As more distributed energy resources are deployed on the distribution grid, this jurisdictional issue will need to be addressed.

Opportunities:

- **National energy policy.** A national energy policy could go a long way toward integrating additional renewable resources and/or controlling natural gas prices. Each region should determine and define its needs and preferences, and this information should be included in a national policy. The plan must be coherent and consistent.
- **Grid modernization policy that encompasses technology issues.**
- **Rate-supported R&D policy.** One participant mentioned nationally supported or utility-supplied R&D funding as an option; another participant noted that R&D funding used to be included in a rate base but was removed due to budget constraints. There is a match requirement on public money; if a project is good enough for public money, it is good enough for private money.
- **Uniformity of regulation or baseline regulation that covers all 51 jurisdictions to create national standards to create uniform market for vendors, investors, etc., to support innovation.** Uniformity of regulation (i.e., a national standard for regulatory structure) would allow for the creation of a market big enough for an entity to offer a new product or service. Currently, private entities are not investing in utilities because utility R&D is regulated and can have a high burden. Complying with Federal Acquisition Regulation (FAR) rules and other regulations is expensive. Rather than being used for these projects, private funding will be used for investments that do not have this regulatory burden. This is a high-friction environment, and utilities are not considered a good investment.

Message to Policy Makers

Participants were asked what message(s) they would give to policy makers for them to consider when developing future policies so that electricity delivery is not adversely impacted:

- **There needs to be more leadership in policy making to set standards that support innovation and investments in the industry.** Policy makers need to be leaders. There needs to be leadership in policy development, standards, and regulation. After World War II, a lot of direction flowed from utilities to Congress regarding the desired regulatory and policy environment. That flow has fallen apart in the last 15 years, and utilities are trying to restore those relationships.

Necessary Actions

Participants identified the following actions that should be undertaken in order to evolve to a cost-effective, reliable, and resilient grid of the future:

- **Create a national policy that drives standards that support ubiquitous regulatory environments.** National standards are going to be a key component, but with so many entities, a common goal will need to be established.
- **Provide a transition plan to move from traditional business models to new, innovative models that preserve the existing infrastructure to ensure the resilience of the grid.** "Do not throw the baby out with the bath water." Utilities understand that while the current regulatory system is not the best, it is the best they know, so they are working to do business within that framework while the changes occur. The grid is surprisingly resilient, and it should be rewarded. The transition will take a while and different grid versions will need to coexist; the grid needs to come together so the sum is larger than the parts. Utilities need clarity about evolving changes so that they can plan accordingly and continue to provide services to consumers throughout the transition.
- **Make the investments needed to modernize the grid and enable the collection and better utilization of data to improve asset utilization and consumer services.** Concerning operations, electricity providers need to implement twenty-first-century technology to collect and use the data they need to improve operations. For example, numerous utility operators do not have many of the sensors for smart switching, and they do not have AMI, which provides increased visibility. In this way, they are technologically behind other utility operators. Data from these technologies is very valuable because of the knowledge and actionable conclusions that can be derived from it.

Conclusion and Next Steps

The Northeast Region workshop provided an interactive forum for participants to identify a vision of the future grid based on their given scenario from a Northeast Region perspective. Stakeholders participated in productive discussions, and the output from this workshop represents an excellent step in gathering viewpoints from stakeholders nationwide. Participants appreciated the opportunity to hear the perspectives of various stakeholders and to discuss future challenges.

Output from this workshop, as well as from the previous regional workshops and the National Summit in Washington, DC, will feed into a final report, which will be published in the last quarter of 2014.

Appendix A. Setting the Stage: Factors to Consider

In order to frame the workshop discussions, participants received pre-read materials describing the scenarios and highlighting a number of key factors to consider that are shaping the electrical grid today and will likely emerge as dominant forces by 2030:

The shift to renewable generation. Rapid growth in wind capacity will continue, boosted by lower-cost, larger-sized turbines; larger production volumes; tax credits; consumer interest; and improved capacity factors. Solar photovoltaics (PVs) will also grow rapidly, driven by higher demand, consumer interest, lower PV module costs, and support from tax credits and other incentives. Although both wind and solar represent a small portion of the total electricity market, in regions where these resources are abundant, they can be disruptive and pose challenges to the grid. Biopower, geothermal, and hydropower will also grow rapidly. Some coal-fired plants may be retired.

The rise of cheap natural gas. Low natural gas prices and tightened emissions requirements will create more demand for natural gas from the power sector. Natural gas generation will grow through 2050, as low costs make existing natural gas plants more competitive with coal, and lower capital costs make natural-gas-fired plants a viable choice for new generation capacity.

Growing building energy efficiency. Growing federal adoption of Leadership in Energy & Environmental Design (LEED) standards for new building construction and state programs such as California's Zero Net Energy Building initiative will drive a broader growth of high-efficiency residential, commercial, and industrial building efforts that also feature on-site renewable energy generation or the purchase of renewable energy from utilities. The renewable requirements and possibility of on-site generation will greatly affect the performance of the grid, both locally and holistically, with implications for grid operation and stability.

The maturing of demand response. There will be increased availability of demand-side management to reduce peak demands, which in turn may help defer new generating capacity or improve operator flexibility in day-ahead or real-time operations. Dynamic pricing, time-of-use pricing, incentive payments, and other strategies will encourage users to change their energy consumption patterns. State policies and federal technical assistance, research, and development will help drive adoption of demand response.

The smart grid. In response to aging infrastructure and a desire to increase electricity transmission and distribution efficiency, there will be an increased push for technology that utilizes remote controls and automation to better monitor and operate the grid. Increasingly over the past decade, Congress has taken a serious interest in electrical grid issues by passing various laws to address them. Title XIII of the 2007 Energy Independence and Security Act includes language specific to the smart grid. Congress continues to consider new legislation to address cybersecurity concerns, privacy and data access for consumers, and other policies to accelerate investments in the future grid.

Growth in energy storage. Maturing energy storage technologies will provide flexible solutions throughout the electricity value chain, helping grid operators address energy management, the intermittency of renewable power sources, and power quality issues.

Increase in microgrids. North America was the leading microgrid market in 2013, and it will remain so in the future, with major growth expected in the United States and worldwide. With the U.S. Department of Defense as an early adopter, and public investment in microgrids from a variety of other state, federal, and university entities, microgrid integration will be a crucial element in addressing grid reliability and resilience issues associated with energy generation from distributed renewables, power outages from natural disasters, and the increasing impacts to national security.

Smart cities and smart appliances. The amount of data being created and collected by municipalities and utilities is growing rapidly; by some estimates, it is expected to double every two years until 2020. Understanding and leveraging this data will be critical for municipalities. To maximize participation in smart cities, stakeholders will need to plan grid development in conjunction with planning authorities. Residential "smart appliances" are expected to become increasingly mainstream in 2015 and could reach up to $35 billion in sales by 2020.

The rise of electric vehicles (EVs). EV sales account for less than 1% of total new light-duty vehicle sales, but federal support, state support, purchasing incentives, and fueling costs are aimed at boosting their adoption. The ways in which charging will impact the grid remain to be seen. The U.S. Department of Energy is encouraging more workplace charging. Technology advances could make quick chargers, wireless charging, or other methods more common at home. Utilities will need to evaluate their distribution system against these possible demand scenarios.

Overall growth in energy demand, with higher industrial demand and lower residential demand. Overall energy use is expected to increase by 2040. The U.S. Energy Information Administration (EIA) projects industrial-sector energy use to grow by 5.1 quadrillion British thermal units by 2040, primarily due to the increased use of low-priced natural gas and an increase in industrial shipments. However, EIA projects average electricity demand per household to decline by 6% by 2040.

A rising frequency of extreme weather events. Weather-related issues are the cause of nearly half of U.S. outages and are on the rise, meaning that grid resiliency will need to be addressed. In light of Superstorm Sandy, local leaders are considering options for local generation to address the most critical loads. Investments are being made in distributed power systems.

Policy and regulation. The grid will need to accommodate, forecast, and communicate with renewable generation resources spurred by renewable portfolio standards. The continuation of existing demand response policies would lead to a 4% reduction in U.S. peak demand by 2019. Renewable requirements for buildings and the possibility of on-site generation greatly affect the performance characteristics of the grid. Some states have launched emissions goals and cap-and-trade programs that may affect electric power producers and industry and shift production toward renewables.

Aging infrastructure and limited addition of new transmission capacity. Much of the U.S. power infrastructure is outdated and needs to be refurbished, replaced, or upgraded. Updating the existing infrastructure will present many challenges. These updates will become more and more necessary as the age of the infrastructure begins to show. Utilizing smart grid technology will increase grid resilience, efficiency, and reliability. The federal government has allocated billions of dollars to replace, expand, and refine grid infrastructure.

Appendix B. Workshop Agenda

GRIDWISE ALLIANCE

The Future of the Grid: *Evolving to Meet America's Needs*

Tuesday, May 13, 2014 • 7:30 am – 4:00 pm
Frank J. Guarini Center on Environmental, Energy, and Land Use Law
New York University School of Law • 245 Sullivan Street • *New York*, NY *10012*

7:30 am **Registration and Continental Breakfast**

8:00 am **Welcome**

Becky Harrison, *CEO, GridWise Alliance*

Eric Lightner, *Director, Federal Smart Grid Task Force, US Department of Energy Office of Electricity Delivery and Energy Reliability*

8:10 am **Opening Remarks**

Richard B. Stewart, *University Professor and Faculty Director, Frank J. Guarini Center on Environmental, Energy, and Land Use Law*

8:25 am **Stage Setting: External Factors and Variables Impacting Future Electricity Delivery**

Hon. Patricia Acampora, *Commissioner, New York State Public Service Commission*

8:50 am **Visioning Exercise: A Future Grid – Capabilities and Functions**

Facilitated discussion with the entire group

If you were starting with a "blank sheet of paper" and did not have any constraints that are imposed by the legacy infrastructure and business models:

- How would you define the future role of the grid?
- What would the future grid look like?
- What capabilities and functions would be necessary to meet society's needs?
- What do grid operations look like?

9:25 am **Break**

9:35 am **Breakout Sessions**

Participants will be assigned to one of the following breakout sessions. A description of the scenarios will be provided in the pre-read materials. Breakout group assignments will be given to participants during registration.

Scenarios

- The Challenge of Balancing Supply and Demand as Grid Complexity Grows
- The Challenge of Involving Customer and Their Electrical Loads in Grid Operations and Planning for Empowered Customers
- The Challenge of Higher Local Reliability Through Multi-Customer Microgrids
- The Challenge of Transitioning Central Generation to Clean Energy Sources – Big Wind, Big Solar and Big Gas

Scope and Task

In the afternoon session, each breakout groups will be reporting out on their Grid of the Future, which is based on their scenario, and will provide answers to the following questions:

- What capabilities or functionality will the grid need to have?
- How will the operations center function?

Scope and Task Continued

- What is the one technical limitation or operational constraint that a policy maker would need to know when developing future policies so as not to adversely impact electricity

delivery?
- What three actions must be undertaken in order to evolve to your cost effective, reliable, and resilient grid of the future?

9:35 am **Breakout Group Discussion: *Defining Grid Operations***

For both the transmission and distribution systems:

- How does the grid have to evolve to get from where we are today to the future vision?
- What capabilities and functions will it need to have?
- How will the operations centers function (distribution, transmission, ISO)?
- How will the interaction between transmission, distribution and the independent system operator change?
- What are the technical capabilities that will be needed that don't exist today?

11:05 am **Breakout Group Discussion: Business Models and Investments**

- What market structure changes, if any, will be necessary to ensure the future viability of utilities and to move from a commodity to services model?
- How will grid owners/operators make money (rate based versus performance based)?
- What will be the new investment and funding requirements?
- How will both capital and O&M costs be covered?

12:00 pm **Lunch**

12:45 pm **Breakout Group Discussion: Regulatory and Policy Barriers and Opportunities**

- What are the policy and regulatory barriers at the state and federal levels?
- Do regulatory bodies have the authority they need to make the necessary business model changes?
- Are there opportunities that must be embraced now?

1:40 pm **The Path Forward: Articulating Your Vision for Report Out**

- Provide answers to the questions posed in the Scope and Task section above.
- Select a spokesperson to present the group's vision
- Select 4 "panelists" who represent different stakeholder groups to participate with the spokesperson for the Q&A session

2:10 pm **Break**

2:20 pm **Report Outs**

Breakout groups will report the results of their discussions back to the larger group. Breakout groups will have 5-7 minutes to present their vision followed by a 10 minute Q&A session.

3:45 pm **Summary and Final Thoughts**

4:00 pm **Adjourn**

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Appendix C. Attendees

Patricia Acampora
New York State Public Service Commission

Erin Alvino
Navista

Howard Andres
Energetics Incorporated

Richard Barone
Navigant Consulting

Sonja Berdahl
National Renewable Energy Laboratory

Diane Blankenhorn
PSEG

Robert Broadwater
EDD

Laney Brown
Iberdrola USA

Tanya Burns
Energetics Incorporated

Ward Camp
Landis+Gyr

Steven Casey
Northeast Utilities

Lee Coogan
GridWise Alliance

Theresa Czarski
Maryland Office of People's Counsel

Michelle Dallafior
U.S. Department of Energy

Ben Davis
Massachusetts Department of Public Utilities

Charles Deberry
Accenture

Rich Dewey
New York Independent System Operator

Jeffrey Donne
Robert Bosch, LLC

Tom Dunn
VELCO

Justin Eisfeller
Unitil

Mike Elzey
Ernst & Young

Ladeene Freimuth
GridWise Alliance

James Gallagher
New York State Smart Grid Consortium

Kimberly Getgen
Tollgrade

David Hallquist
Vermont Electric Cooperative

Becky Harrison
GridWise Alliance

Steven Hauser
New West Technologies, LLC

Paul Hines
University of Vermont

Kerrick Johnson
VELCO

Michael Jung
Silver Spring Networks

Anna Kleber
Bosch

Artie Kressner
Grid Connections, LLC

Lee Krevat
San Diego Gas & Electric

Jayant Kumar
Alstom Grid

Jackson Lehr
National Grid

Eric Lightner
U.S. Department of Energy

Joseph LoPorto
PHI

Rebecca Massello
Energetics Incorporated

Paul McCurley
NRECA

Jeffrey Mittler
Pepco Holdings

Bryan Nicholson
GridWise Alliance

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Smart Grid Consortium

Jonathan Schrag
NYU School of Law

Forrest Small
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Meghan Taylor
Modern Energy Insights

Wyly Wade
Civergy

Bruce Walker
SmartSenseCom, Inc.

Matthew Wallace
New York State Public Service Commission

Richard Wernsing
PSEG

William White
Norton White Energy

Michael Worden
New York State Department of Public Service

Katrina Wyman
NYU School of Law

Henry Yoshimura
ISO-New England